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OPERATION AND MAINTENANCE MANUAL, TECS 18.(U)

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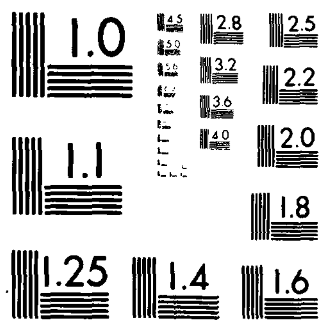

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LEVEL II

OPERATION AND MAINTENANCE MANUAL

TECS 18

12) 139

U.S. ARMY MOBILITY EQUIPMENT
RESEARCH AND DEVELOPMENT CENTER
ENVIRONMENTAL CONTROL SYSTEM
CONTRACT NO. DAAG-53-75-C-0274

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OPERATION AND MAINTENANCE MANUAL TECS 18

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Chapter 1

Specifications and Characteristics of the

TECS Frequency Changer System

I. Introduction

The Welco Industries Total Environmental Control System (TECS 18) operates from multiple frequency power sources to provide solid-state proportional temperature control of both air conditioning and heating. Three independently controlled pulse-width modulated variable frequency inverters provide variable speed control of a compressor, condenser fan and evaporator fan motors. Zero-crossing heat controls provide 5.6Kw proportional heat and 3.8 Kw ON-OFF heat in the two HEAT modes.

The electronic controls are located within ~~the~~ four basic modules ~~shown in Figure 1~~. The Evaporator Drawer contains the system control logic in addition to the inverter drive circuitry for the evaporator fan. The Power Deck contains the main system power supplies and the Comp/Cond Drawer contains the inverter drive circuitry for both the compressor motor and the condenser fan.

It should be noted that the TECS 18 contains no input fuses or circuit breakers to protect against internal shorts, etc. Hence protection must be provided in the power distribution circuit supplying the system. The use of fast rectifier type fuses or instantaneous trip circuit breakers is not required because of the overload protection provided internal to the unit. Fuse types such as FRN or KTK will provide adequate protection to prevent catastrophic damage to equipment. Alternately, fuses designed for the protection of solid-state devices (KAB, KAJ, KBC, etc.) may be used because of the soft-start operation of the TECS system.

II. Specifications

A. Input Requirements

1. The TECS 18 is designed to operate from 208 VAC $\pm$ 10%, 50/60/400 Hz, three phase power sources with greater than 10 KVA capacity.

2. Input Power

OFF Mode	- 15	VA
TEST Mode	- 125	VA
COOL Mode	- 5.5	KVA max.
AUTO-COOL Mode	- 5.5	KVA max.
LOW HEAT Mode	- 6.0	KVA max.
HIGH HEAT Mode	- 10.0	KVA max.

3. Power Factor $\geq$ 0.98 in all modes of operation

4. No frequency sensing required. Operation is independent

of input power frequency.

5. Unit operation is independent of input power phase sequence.

B. Modes of Operation (Figure 1-2)

A manual selector switch provides for operation in any one of five operational modes, plus an OFF mode.

1. OFF Mode

All controlled elements (motors and heaters) are unenergized. A small portion of the control circuitry remains energized to retain fault information.

2. TEST Mode

All electronics function normally except for the high voltage sections. A detailed description is given in Chapter 4, Protection and Maintenance.

3. COOL Mode

Operates the compressor, condenser, and evaporator fan motors. Up to 40% of the proportional heat (2.24 Kw) may come on as determined by the TEMP control knob.

4. AUTO-COOL Mode

Operates the compressor, condenser and evaporator fan motors. Allows the condenser and compressor to cycle on and off as determined by the TEMP control knob.

5. LOW HEAT Mode

Operates only the proportional heaters (up to 5.6 Kw) and the evaporator fan. Fan speed is controlled by the FAN SPEED control knob.

6. HIGH HEAT Mode

Operates the fixed heaters (3.8 Kw) in addition to the proportional heaters (0 to 5.6 Kw) and the evaporator fan.

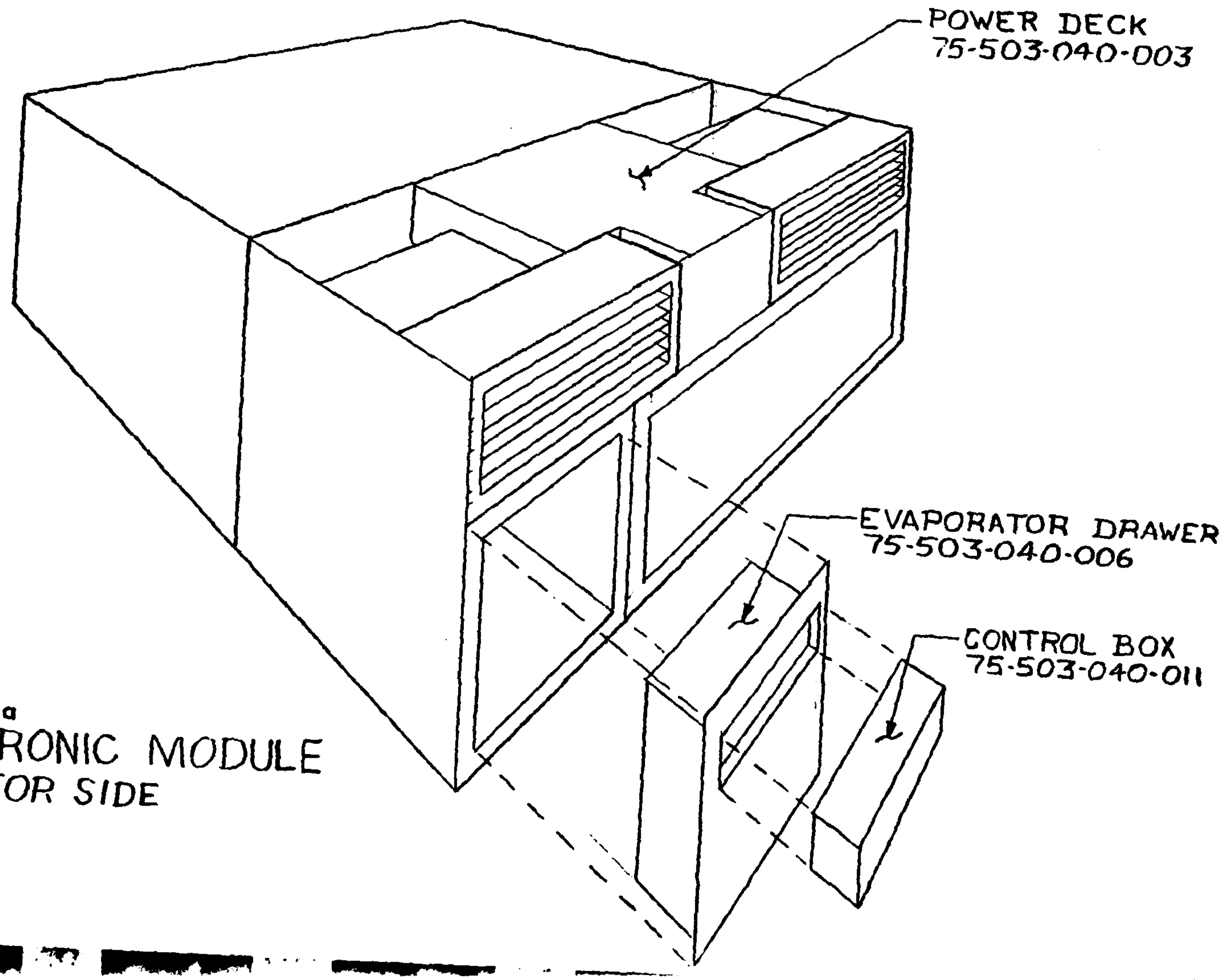


FIGURE 1-1a
TECS 18 ELECTRONIC MODULE
LOCATION-EVAPORATOR SIDE

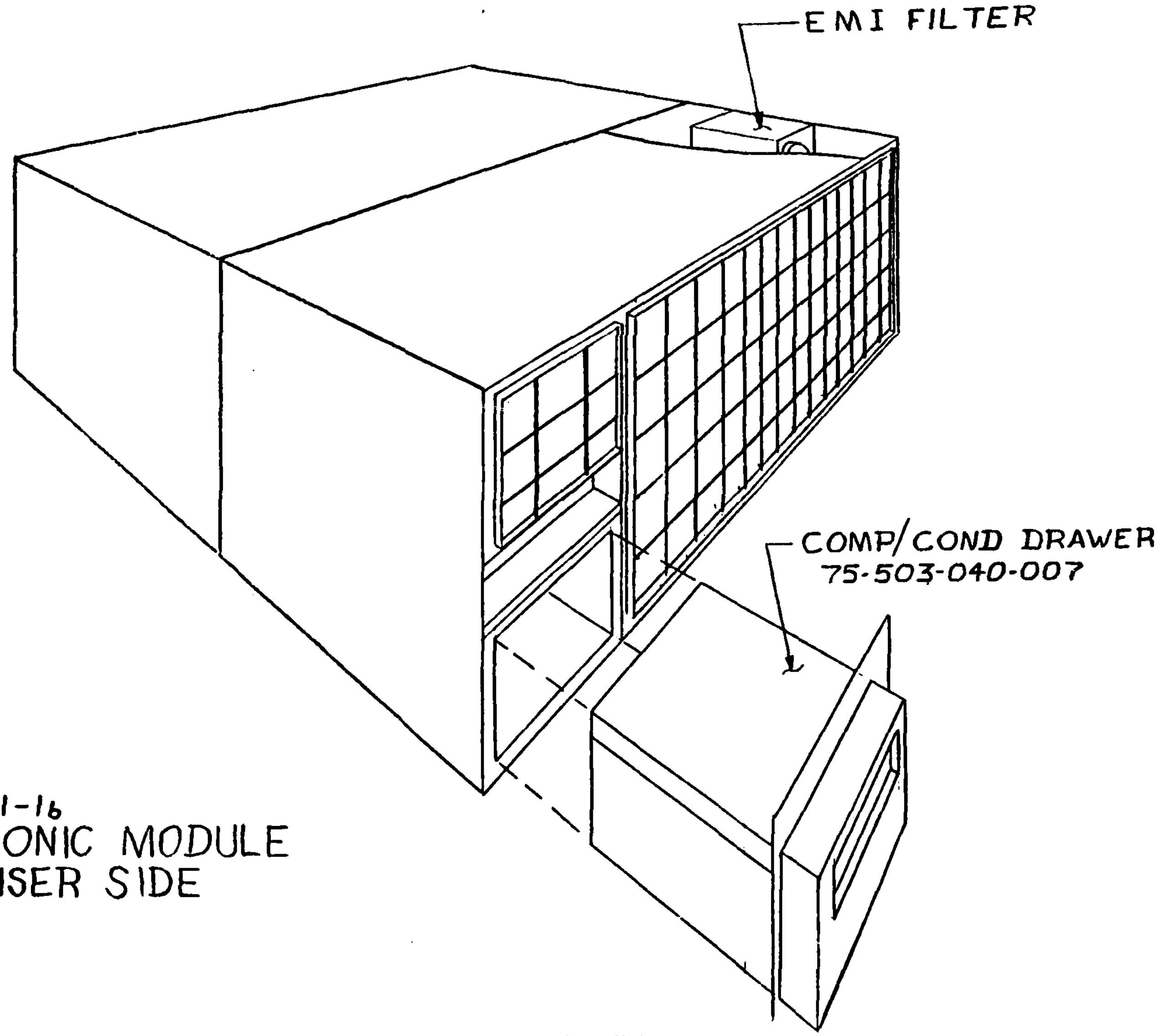


FIGURE 1-16
T.E.C.S. 18 ELECTRONIC MODULE
LOCATION-CONDENSER SIDE

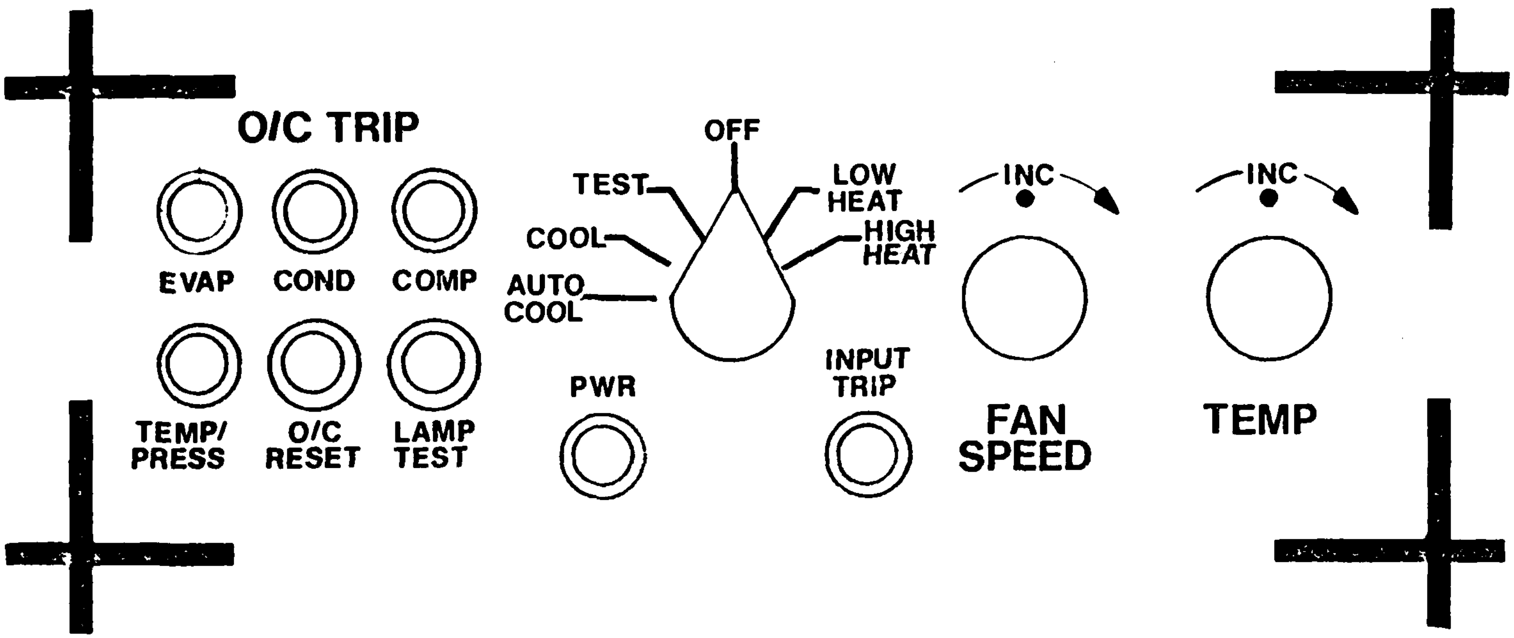


FIGURE 1-2
REMOTE CONTROL PANEL

Chapter 2

OPERATION AND PRINCIPLE FEATURES

I. General Operation

A. Operating Instructions

1. Application of Power (Figure 2-1)

Power is applied to the TECS 18 through one of the MS3102R22-22S connectors - J106 located on the EVAPORATOR DRAWER or through J307 located on the COMP/COND Drawer. An internal connection (located behind the EVAPORATOR DRAWER) selects which connector may be used. If J307 (condenser side) is used it is necessary to connect JP105 to the bulkhead connector J301. If J106 is used JP105 must be connected to J105 on the rear of the EVAPORATOR DRAWER.

The unit is shipped from the factory connected for Evaporator power input.

The TECS 18 is designed for application of three phase, four wire input power with the three input voltages going to terminals A, B & C of the input connector. Terminal D is connected internally to the TECS cabinets and <u>must be connected externally to the power system neutral</u>.

The unit will not operate if single-phase power is applied or if the input voltage falls below 178 VAC.

2. Turning On the Unit

Before applying power to the unit for the first time, make sure the Mode selector switch is in the OFF position. Apply power by closing the circuit at the distribution box, and check for negligible power line currents with a clamp-on ammeter.

a. LOW HEAT/HIGH HEAT

Turn the Mode Selector Switch to LOW HEAT. The green PWR indicator lamp should come on immediately, followed in approximately two seconds by the Evaporator fan motor beginning to turn. The speed of the Evaporator fan motor is controlled by the FAN control knob from 75% to 115% of its base speed of 1750 rpm. Place a clamp-on ammeter on any of the three input power lines. As the TEMP control knob is turned in the direction of INC (clockwise) the line current should increase to a maximum of approximately 15 AMP. (This is a function of ambient temperature and may be less).

Turn the Mode Selector Switch to HIGH HEAT. With the TEMP control all the way counterclockwise, the total line current should be about 10 Amp. With the TEMP control fully clockwise, the line current should be approximately 24 Amp. FAN speed should not change in switching between LOW and HIGH HEAT Modes.

Turn the Mode Selector Switch to OFF. Unit should turn OFF (green indicator lamp OFF and Fan not running) and no line current observable.

b. TEST/COOL

Turn Mode Selector switch to TEST position. The green PWR indicator should come on immediately but fans and heat should not operate. Turn selector switch to COOL, the condenser and evaporator fans should begin turning after a two second delay. The compressor inverter will not turn on for 10-100 seconds (depending on trimmer setting) and will come on with a soft-start and no observable in-rush of current. Observe carefully the line-current to determine the start of the compressor. The amount of cooling is controlled by the TEMP control with full counterclockwise producing maximum cooling. Evaporator fan speed can be independently adjusted to control air flow.

c. AUTO COOL

In the Auto-Cool Mode the Compressor and Condenser fan will turn on only if cooling is required based on air temperature and TEMP control setting. After air temperature has stabilized the compressor and condenser fan will cycle on and off as required to maintain a constant temperature. To shut down the unit turn the Mode Selector switch to OFF through the TEST position.

B. Description of Operation

1. OFF Mode

All electronic drives are in an unenergized state with zero output to all controlled elements. A small portion of the control circuitry remains energized to retain fault information. All Controls (including the RESET and LAMP TEST pushbuttons) are disabled.

2. TEST Mode

The TEST Mode is provided to simplify making adjustments and checking system operation. All electronics of the three inverters function normally, with the exception that the two high voltage DC bridges supplying the inverters are disabled. With the normally high voltage DC bus at zero volts the units operation may be safely checked. All transistor inverter base drives will be present and will turn on at minimum frequency after the appropriate delays, ramping up in frequency to running speeds dictated by transducer

and/or potentiometer settings.

The "LOW HEAT" and "HIGH HEAT" features are also inhibited in the TEST mode to prevent heat buildup when the evaporator fan is not operating.

NOTE: It is necessary to pass throughout the TEST mode to run the unit in COOL mode. Once the manual selector switch has been moved to the COOL mode the TEST feature is rendered inoperative until the unit is shut down by returning the selector switch to the "OFF" position for several seconds.

3. COOL Mode

When the selector switch is moved to the COOL position from TEST a pre-charge "soft-start" circuit immediately begins charging the DC bus to approximately 260 VAC. The main supply for the DC bus is switched in after about one second delay, thereby eliminating Line surges on start. After a two seconds delay the condenser and evaporator base drives will come on. The compressor inverter base drive is inhibited for a variable length of time up to 100 seconds by trimpot adjustment. The inverter base drives come on at a minimum frequency of 6 Hz and ramp up immediately.

a. The condenser inverter will ramp up in frequency to a speed dictated by a sensor monitoring the temperature of the condenser coils.

b. The compressor inverter ramps to its running frequency at a rate of approximately 2 H/sec., and is preset to run between 24 Hz minimum to 60 Hz maximum. Its actual frequency of operation is determined by the front panel potentiometer "TEMP" setting and is automatically regulated to that setting by a thermistor located in the return-air duct. When air temperatur in the compressor condenser section exceeds approx. 120 ° F, the compressor minimum speed is raised to 40 Hz to prevent compressor lock-up.

c. The evaporator inverter will ramp up in frequency at approximately 6 Hz/second. Its running frequency is determined by the "FAN" potentiometer setting mounted on the control panel and is controllable from 45 Hz to 69 Hz (75% to 115% of rated speed).

d. "LOW HEAT" heating elements modulated from 0% to 40% of rated power are automatically controlled by the thermistor located in the return air duct and counter-controlled by the "TEMP" (Compressor) potentiometer.

LOW HEAT and the compressor speed are controlled by the same sensor circuitry to prevent simultaneous high COOL and high LOW HEAT outputs. When the compressor drive frequency is greater than 50% (30 Hz) the LOW HEAT output is zero. As the compressor drive frequency drops below 50% the LOW HEAT

begins to operate and increases its output linearly from one heat pulse per 16 cycles to a maximum of six heat pulses per 16 cycles at a compressor drive frequency of 40% (16 cycles represent one period or time interval for the zero-crossing LOW HEAT sections.

4. AUTO-COOL

a. Condenser fan operates as described in the "COOL" Mode, except that the condenser fan is stopped whenever the compressor is not operating.

b. Compressor operates as described in "COOL" Mode except that whenever the temp sensor and TEMP potentiometer slows the compressor to its minimum speed (24 Hz) the compressor (and condenser fan) are turned off rather than continuing to operate at their minimum speeds. If air temperature raises or TEMP pot setting is lowered the compressor and condenser fan will restart as described in "COOL" Mode.

c. Evaporator fan operates as described in "COOL" Mode.

d. Low heat, heating elements are disabled.

e. High heat, heating elements are disabled.

5. "LOW HEAT" Mode

a. Condenser fan motor OFF, & high voltage DC bus is off.

b. Compressor motor OFF, & high voltage DC bus is off.

c. Evaporator fan motor modulated from 75% to 115% rated speed with the FAN control potentiometer.

d. "LOW HEAT" heater elements modulated from 0% to 100% rated power (5.6 Kw) automatically regulated by a thermistor located in the return air duct with the temperature.

6. "HIGH HEAT" Mode

a. Condenser fan motor OFF, & high voltage DC bus is off.

b. Compressor motor OFF, & high voltage DC bus is off.

c. Evaporator fan motor modulated from 75% to 115% rated speed with the FAN control potentiometer.

d. "LOW HEAT" heater elements modulated from 0% to 100% rated power 5.6 Kw automatically regulated by a thermistor located in the return air duct with the temperature control potentiometer located on the control panel. A thermal

switch located over the heater elements acts as a high temperature safety to shut down power to the elements.

e. "HIGH HEAT" heater elements are operated at 100% power (3.8 Kw) with a thermal switch located directly over the heater elements for ON/OFF control as a high-temperature safety-switch.

II. Principle Features

A. Frequency Changer

The Environmental Control System contains three independent pulse-width modulated frequency changers with similar characteristics operating from a common power converter DC bus.

1. Power Converter (Figure 3-3)

The power converter changes the 50/60/400 Hz, 3Ø, 208 volt supply to two direct voltage supplies with amplitudes of approximately 290 VDC. It is composed of two 3 SCR - 4 Diode (three-phase-full-wave) converters, a single-section L-C filter, a single section RC filter, an over/current and low voltage/missing phase sensor detector. The power converter is independent of frequency and phase sequence as well as line voltage. Silicon-controlled rectifiers are used as switches to turn the DC busses ON or OFF.

2. Inverter (Figure 2-3)

The inverter changes the direct voltage to a three phase pulse-width modulated variable output voltage and frequency using a three-phase transistor bridge circuit. Reduced power line electromagnetic interference, lower motor losses, compact size and weight and reduced complexity are principle advantages of the PWM technique. Fault detection and trip circuitry are incorporated to protect against internal and external faults.

3. LOW-HEAT Section utilizes zero-crossing switching proportional control of thyristors to provide excellent control of heat with minimum EMI generation.

4. HIGH-HEAT Section utilizes a solid-state zero-crossing relay to apply or interrupt power with minimum EMI generation.

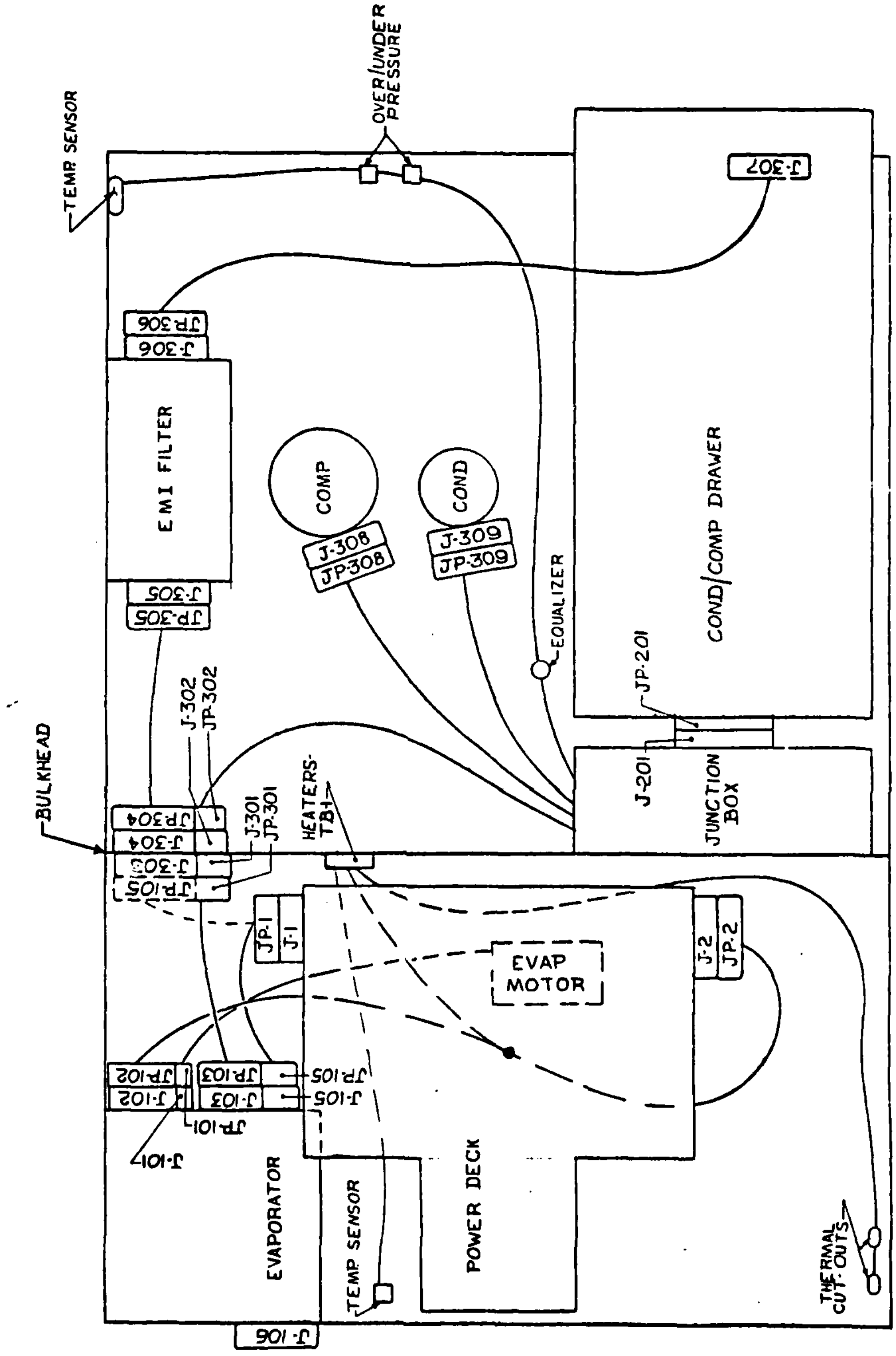


FIGURE-2-1
WIRE HARNESS AND CONNECTOR DESIGNATIONS

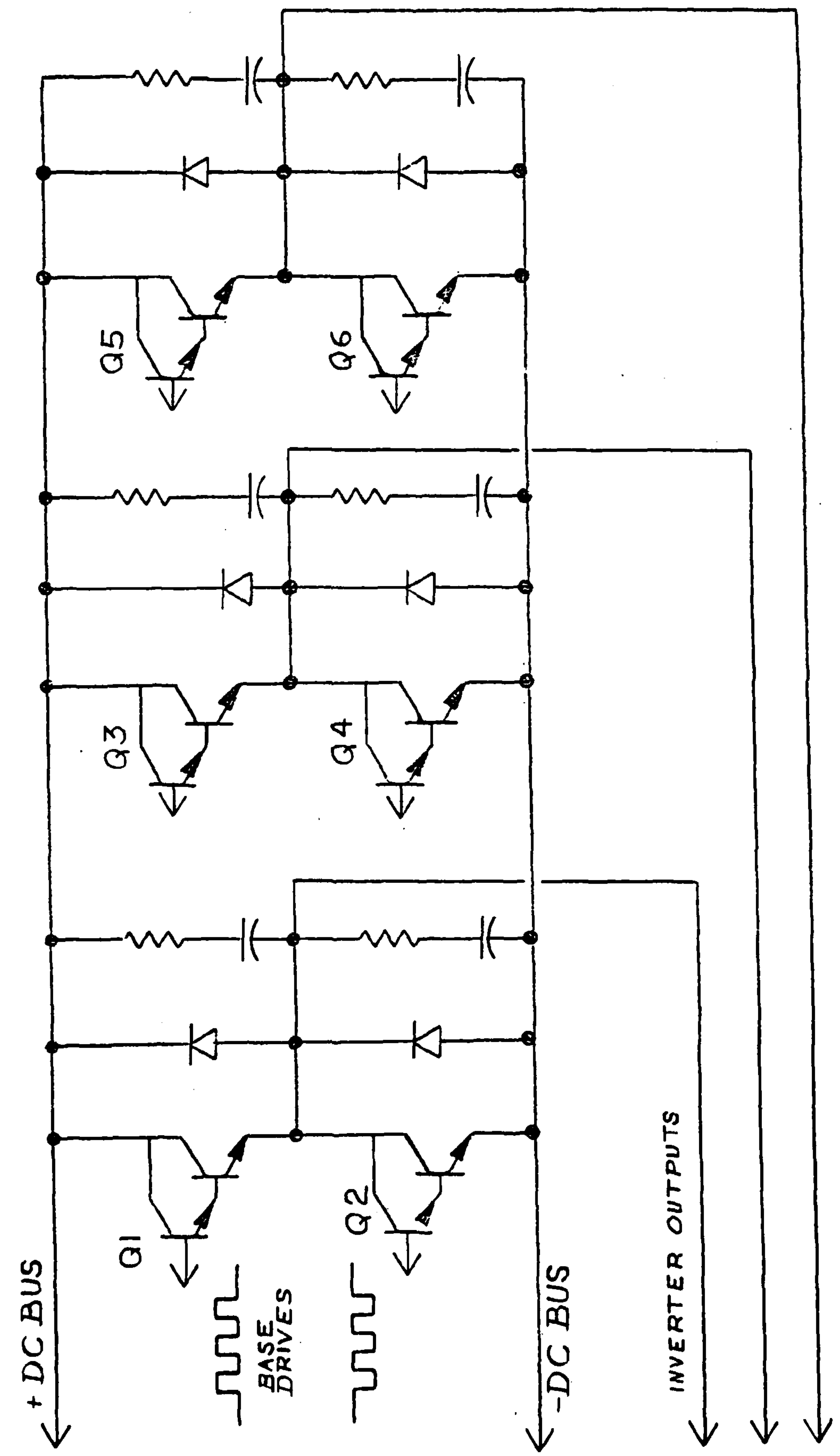


FIGURE 2-2 BASIC INVERTER

Chapter 3

Principles of Operation of the TECS 18

Environmental Control System Frequency Changer

I. Technical Description

The Welco TECS 18 is an integrated all solid-state environmental control system to provide heating, air conditioning and ventilation from multiple three-phase power sources. The system consists of a solid-state zero-crossing ON/OFF "high heat" 3840 watt unit, a solid-state zero-crossing proportional controlled "low heat" 5760 watt unit, a 18000 BTU compressor inverter drive over the range of 40 - 100% speed with a normally open solid-state controlled equalizer solenoid, a condenser fan inverter with a TEMP transducer-controlled 10-100% speed range and an evaporator fan inverter with 75 - 115% manually controlled speed range. A system block diagram is shown in Figure 3-1.

II. Circuit Fundamentals

Because the three inverters operate according to the same basic pulse-width modulation principles, the fundamentals of operation will be presented as common to all.

The "Low and High" heat heater controls both use the same technique of zero-crossing TRIAC control with only the "Low Heat" unit proportionally controlled.

A. Pulse-Width Modulation Technique (Figure 3-2)

A voltage controlled oscillator (VCO) on the Frequency Control Board generates a variable frequency clock signal CL1 with a frequency twenty-four times the fundamental output frequency. Clock CL1 is used to generate three sinusoidal reference waveforms Va, Vb, Vc as shown in Figure 3-2b.

A second oscillator on the Frequency Control Board generates a fixed frequency clock signal CL2 which is used to produce the variable amplitude triangular reference signal V_T. V_T is compared to Va, Vb, & Vc to produce the sinusoidualy referenced Pulse-Width Modulated (PWM) control signals which are applied to the inverter circuit of Figure 2-2. Line-to-Line output voltages are shown in Figure 3-2f result.

Output voltage is inversely proportional to the amplitude of reference signal V_T, therefore voltage control is achieved by controlling this amplitude. A high gain comparator (compensated to insure stability) is used with a voltage feedback signal to correct for the inherent non-linear relation between V_T and output Voltage, so that a constant V/F output ratio is achieved.

B. Advantages of PWM

The DC Busses are provided by controlled rectifiers, which are not

used to vary the Bus voltage so that no voltage and current pulses or abrupt turn-on discontinuities occur making EMI filtering requirements much less than with phase-controlled rectifiers.

2. A considerable reduction is achieved in filtering requirements to produce the DC Busses because of no discontinuities presented tc the input.

3. System ground is common for all three inverters. This also reduces system interconnection requirements and cabling weight. The cabinets of the TECS are connected to Logic ground to facilitate testing and trouble-shooting.

4. The power factor of the input for an uncontrolled bridge rectifier is close to unity throughout the various speed ranges of the system This is in contrast to phase-controlled thyristor bridges which operate close to unity power factor only when full on.

III. System Description

The heart of the Environmental Control System (TECS) are the frequency changers (converter/inverters) which accept power from three-phase, 50/60/400 Hz sources and convert it into three-phase, variable frequency, variable voltage supplies for motor loads.

The basic frequency changer can be divided into three separate sections:

a. Power Control Section

b. Transistor Inverter Section

c. Electronic Control Section

A. Power Converter Section (Figure 3-3)

The function of the power converter section is to convert the input three-phase alternating voltages to a low ripple DC voltage to power the inverter sections. The principle components of the power converter section are 1) Two three SCR 4 diode bridges; 2) DC bus pre-charge circuits (auxiliary supply); 3) An L-C filter; 4) A current sensing and shut-down protection circuit; 5) An R-C filter for the evaporator Bus.

1. Three SCR-Four Diode Bridge (Main Supply)

The six-phase (3Ø full-wave, half-way) bridge is utilized because of the higher frequency ripple (6 times the input frequency) when full-on and because of its capability to block in order to turn off the DC bus. The basic circuits are shown in Figure 3-3. A continuous gate current of approximately 0.3a is applied to each SCR during operation to insure full conduction and minimum conducted EMI.

2. The DC precharge circuit is incorporated via thyristor Q4 to charge the capacitances of the DC bus filter slowly through a power resistor and yields three important benefits: a) It eliminates line current surges at turn-on. b) It protects the SCR's in the main DC bus supply against di/dt failure caused by current surges in charging the filter capacitors. c) It eliminates the stress on the dielectric of the filter capacitors, reducing the possibility of a capacitor "blow-out". The precharge circuit immediately begins to charge the DC bus when the control is moved into COOL or LOW HEAT. After approximately one second the main SCRs in the three SCR-four diode bridge are gated, completing the turn-on of the DC bus.

3. Filter

   The purpose of the filter is to reduce the ripple content of the bus voltage applied to the inverter to a satisfactory level and thus keep motor losses down. The basic filter circuit is also shown in Figure 3-3. Because the thyristors are operated only in full-on or blocking modes, the unfiltered ripple magnitude is small, considerably reducing the filter size.

4. Overcurrent/undervoltage/Single-phase Protection

   A 0.018 ohm resistor in the DC bus supply lines, shown in Figure 3-3 monitors the current drawn by the three inverters and shuts down the power converter if more than 60 amperes flows through the resistor. An undervoltage circuit monitors the power line voltage and provides a shutdown of the power converter.

B. Transistor Inverter Section

The inverter is a six-step bridge-type inverter utilizing power switching transistors, the schematic of which is shown in Figure 3-4a. The transistors are enabled for a full half cycle with gating order 1-6-3-2-5-4. The base drive to each transistor is generated with fast rise and fall-times of 200 nsec. A typical base drive wave-form depicting negative bias and time delay between gates of complementary section for reliable operation is shown in Figure 3-4b.

Current sensing is built into each transistor bridge phase to monitor its current. A current in excess of a preset value will trigger a monostable for momentary base drive cut-off. Repeated activation of this protection circuit indicative of a faulty power transistor or shorted output will cause the inverter to shut down before another transistor can be damaged.

Both voltage and frequency are linearly controlled by the logic ramp signal which can vary from 1.0 V to more than 10 V. Figure 3-5 shows the voltage-frequency relationship of the outputs and the ranges of frequency over which the three inverters are controlled. Only the evaporator fan has the capability to overspeed beyond its motor base speed of 1750 rpm in order to compensate for increase in back pressure caused by ductwork.

C. Electronic Control System

When the system function switch is moved from the OFF position to any other position, power is supplied to the DC-DC converter section which in turn supplies control power to the three transistor inverters and to the power converter bridge. All inverter transistor bases, however, are negatively biased (held in an OFF state) for a short time after the function switch is moved to "COOL" or "LOW HEAT". After a short delay, approximately 1.0 second for the evaporator and condenser and 30-90 seconds for the compressor, dictated by the monostable circuitry located on the Master Control Board, the base drive circuits on the Inverter Control boards are enabled, allowing base drives to be applied to the inverter transistors. Simultaneously the integrating comparators on the Inverter Control Boards are released by JFET control to ramp up to the signal level determined by their sensor/control circuitry.

Note A - When the function switch is moved to the TEST position from OFF, all transistor base drives are enabled and allowed to ramp up in a normal fashion. In this mode the DC bus which supplies the inverters is disabled by removing gate signals to the SCRs of the converter. This allows the operator to check the logic operation of the inverters without high voltages to them. Caution must be used at all times when working with the system, however, to insure that the DC bus voltage is zero volts before testing.

Note B - EXTREME CAUTION IS RECOMMENDED WHEN USING GROUNDED TEST EQUIPMENT TO INSURE AGAINST IMPROPER GROUNDING OF THE POWER SECTION. IT IS NOT ISOLATED AND DAMAGE TO TEST EQUIPMENT AND THE TECS 18 MAY RESULT FROM IMPROPER USE.

Note C - WHEN USING "ISOLATED" OR "FLOATING" TEST EQUIPMENT TO MONITOR THE POWER SECTION, HIGH VOLTAGES TO GROUND MAY BE PRESENT ON THE TEST EQUIPMENT CABINET(S) AND MAY POSE A HAZARD TO PERSONNEL AND EQUIPMENT.

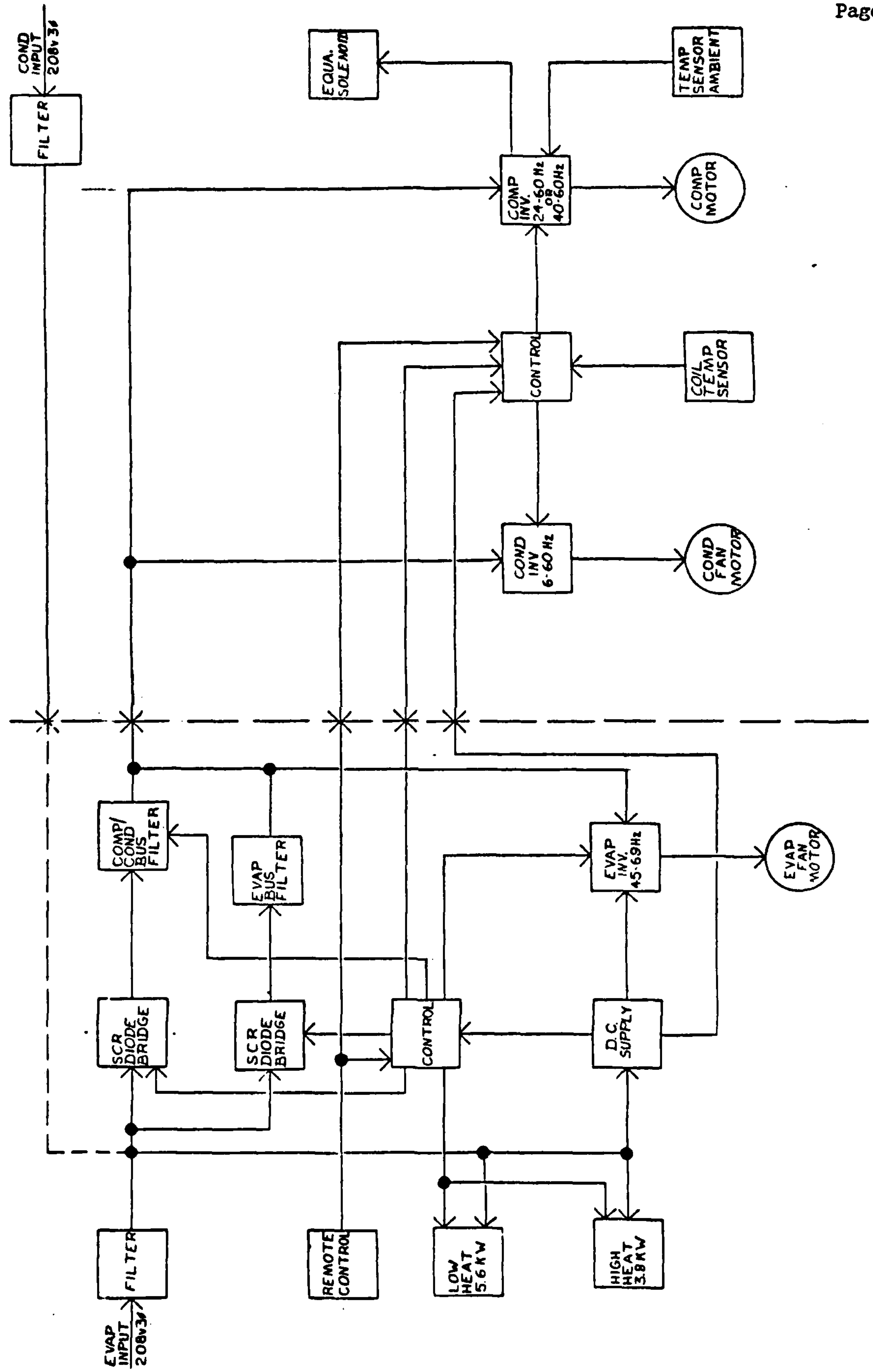


FIGURE 3-1 TECS BLOCK DIAGRAM

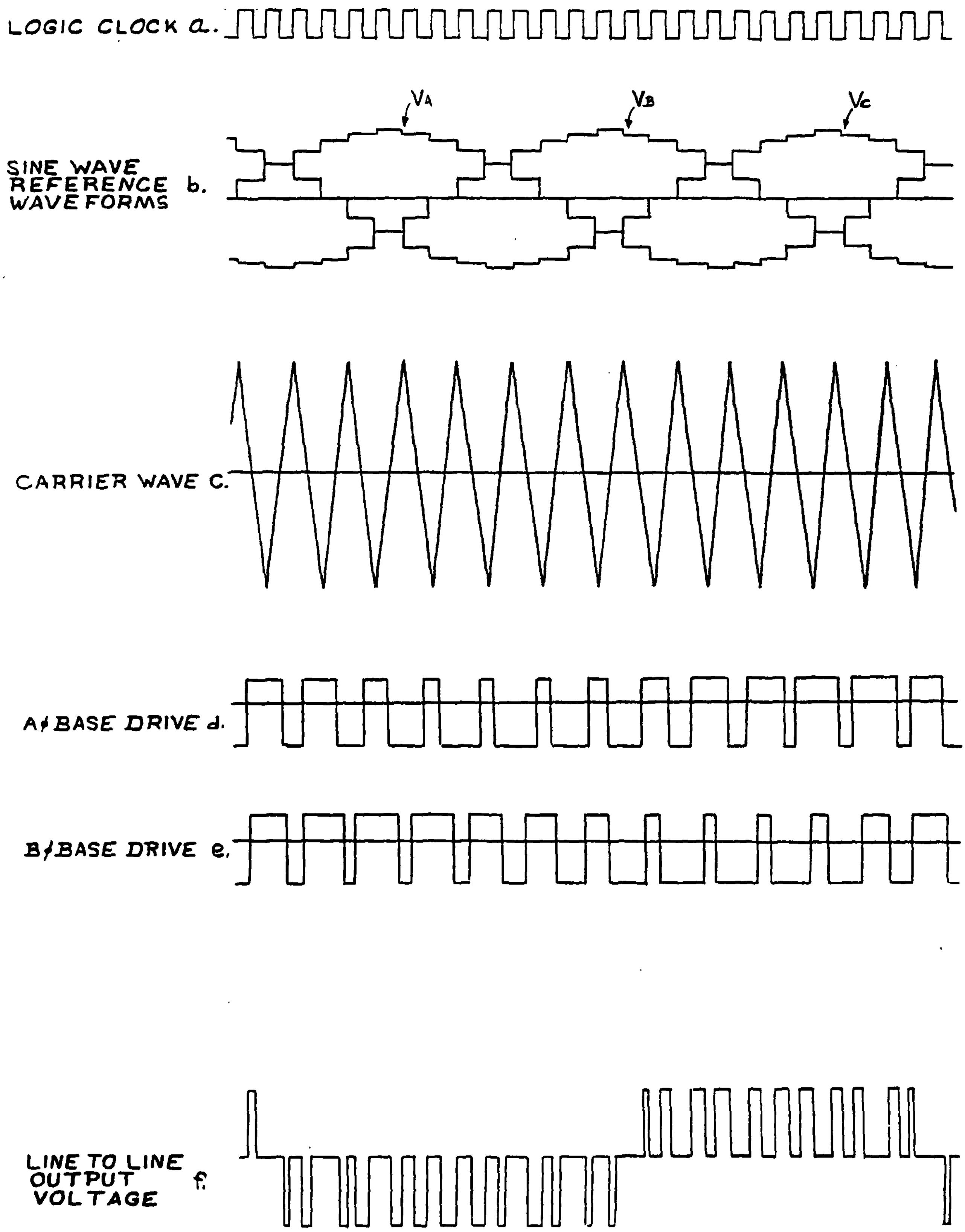


FIGURE 3-2
P.W.M. WAVEFORMS

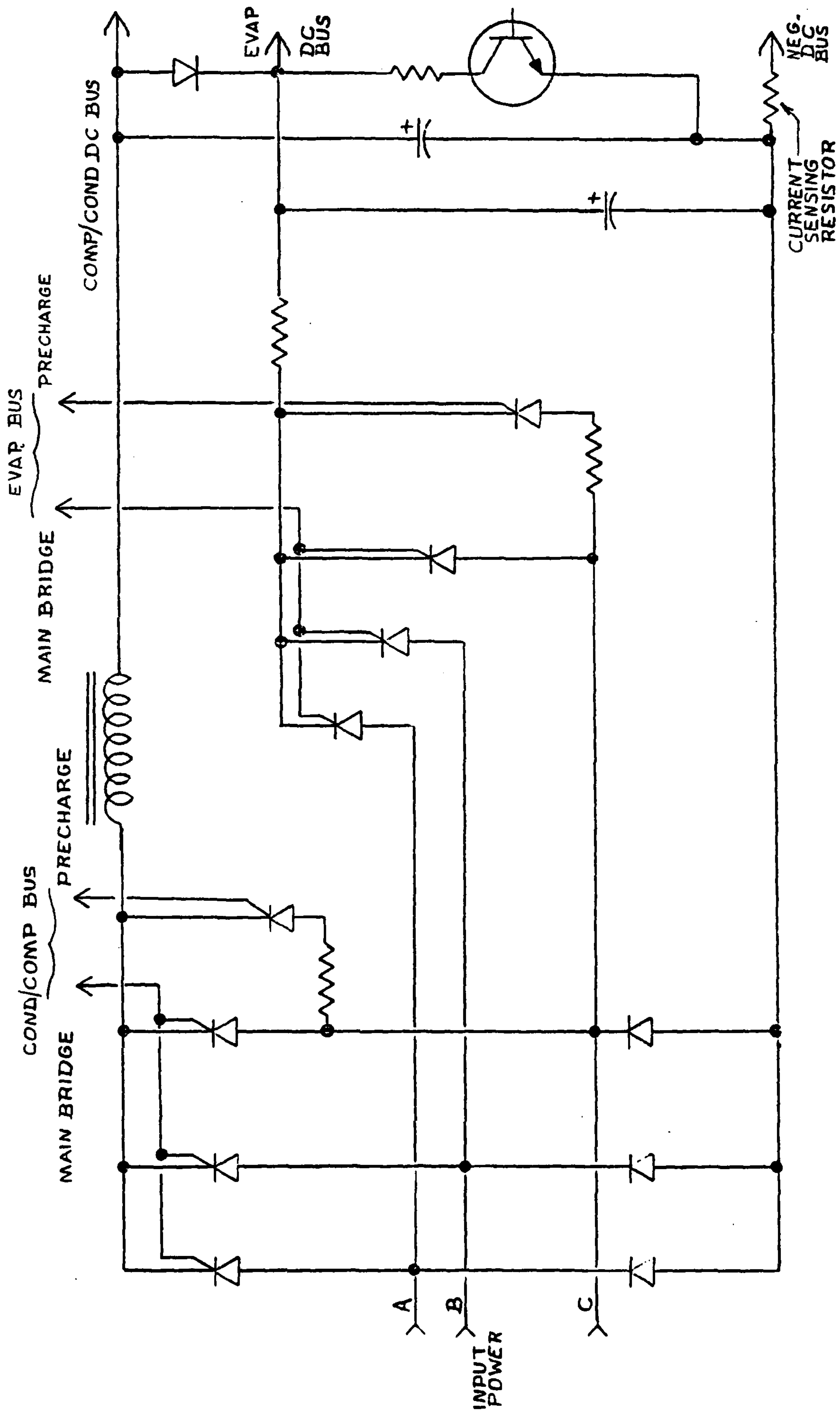


FIGURE-3-3
POWER CONVERTER SECTION

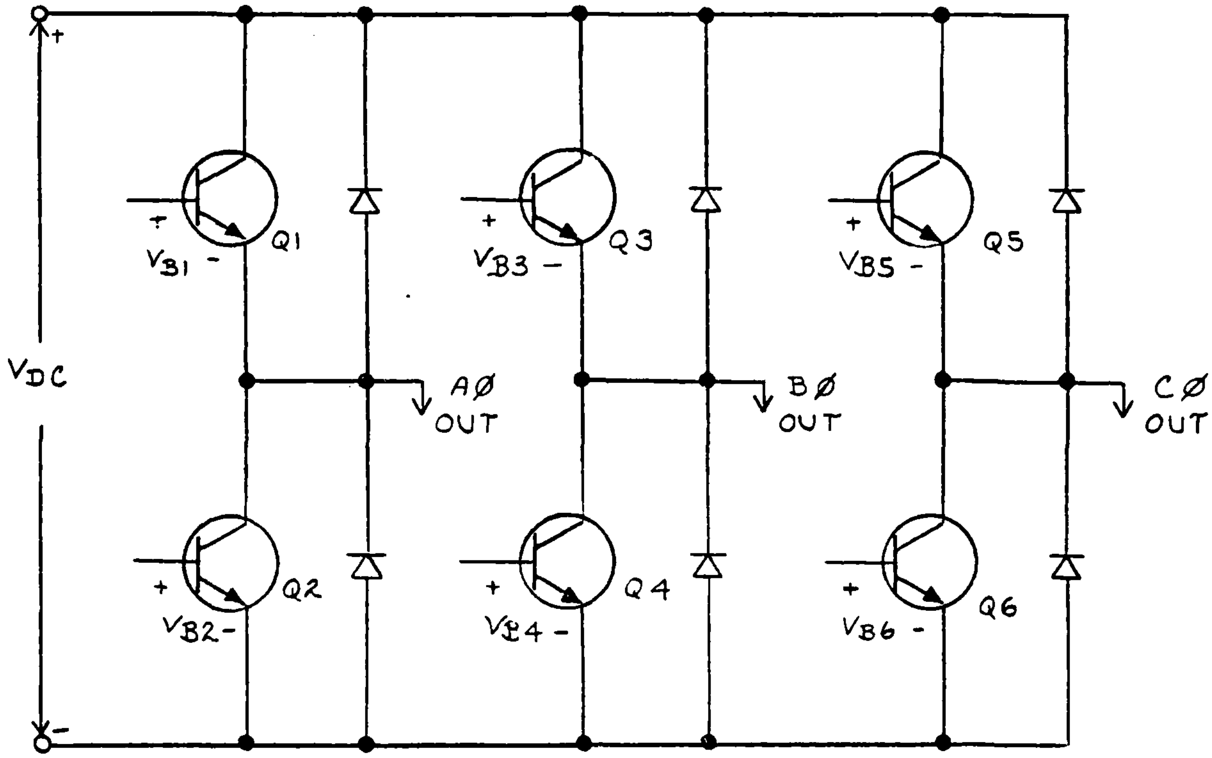


FIGURE 3-4A BASIC INVERTER

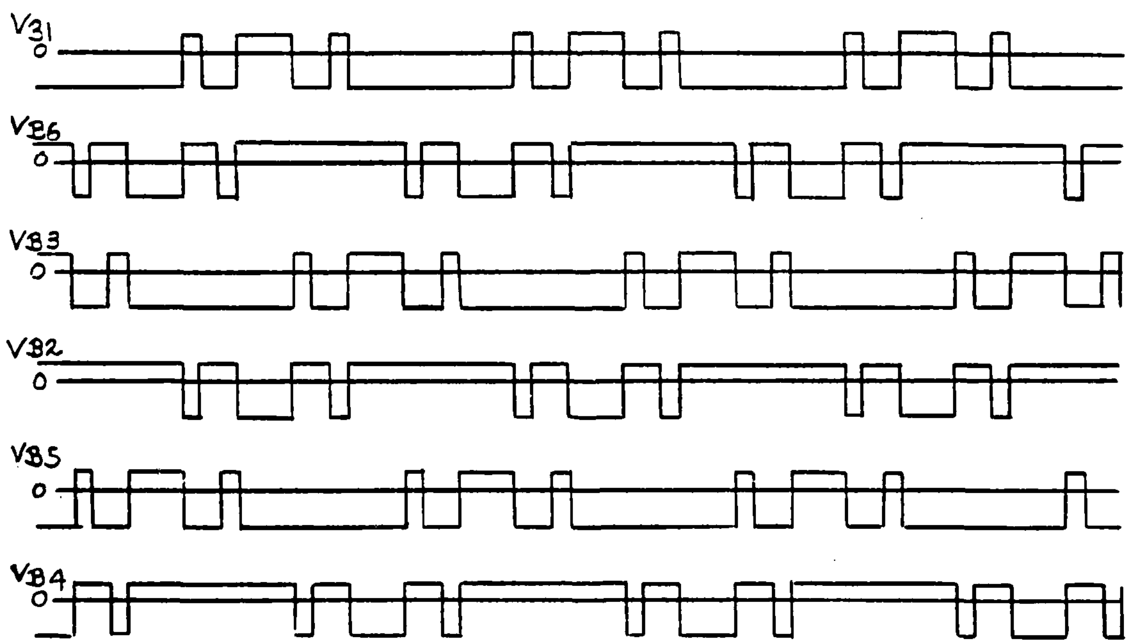


FIGURE 3-4B BASE DRIVES (HIGH-OUTPUT)

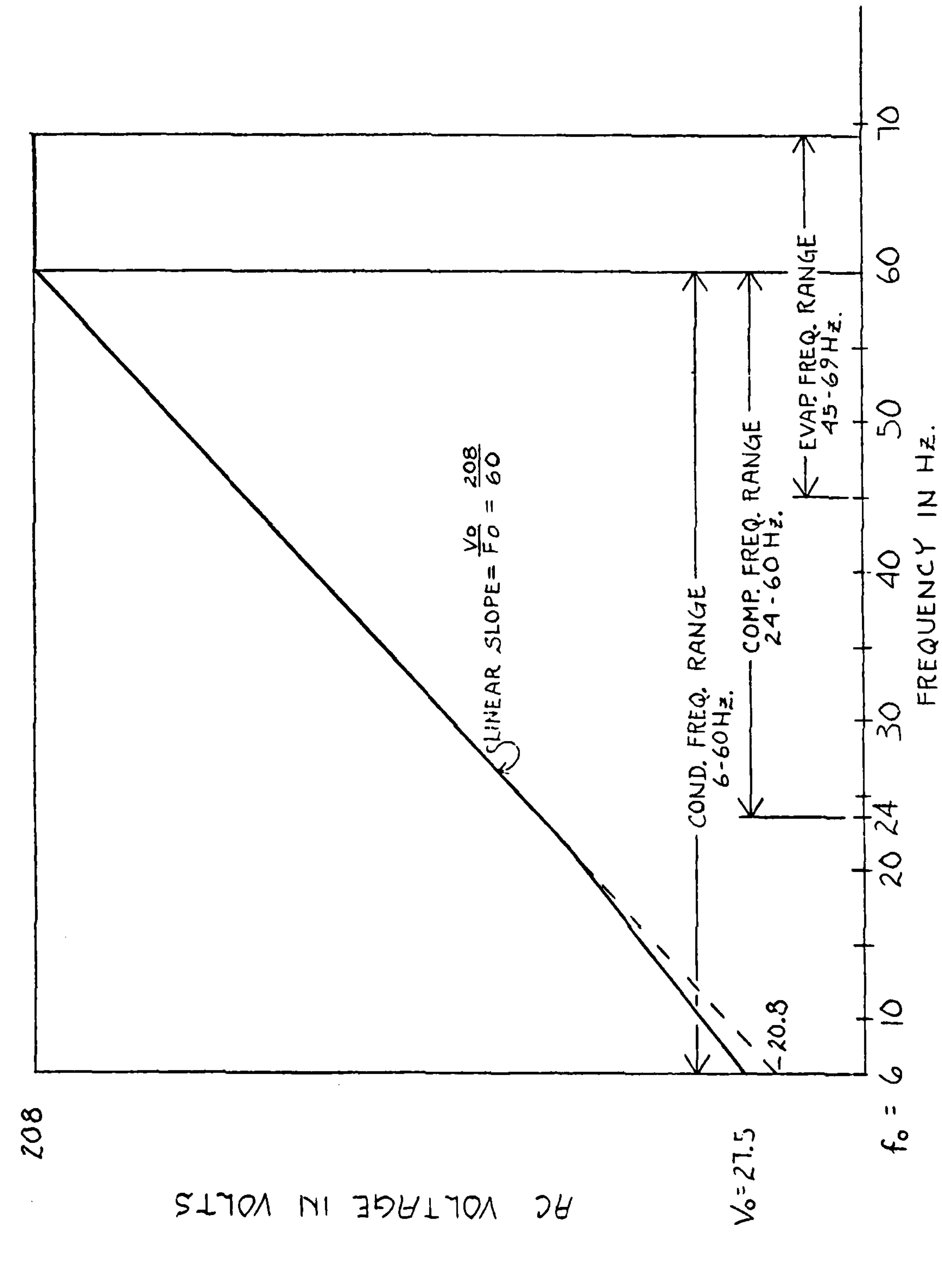


FIGURE 3-5 AC VOLTAGE vs FREQ.

Chapter 4

Protection and Maintenance

I. Internal Protection Circuitry

A variety of electronic protection circuits are provided to prevent operation under conditions which could result in a partial or catastrophic failure in the TECS 18. Automatic system shut-down will occur if internal temperatures of motors exceed safe operating limits, if internal currents exceed safe limits, if coolent pressure exceeds the maximum or falls below minimum pressure settings, or if input voltage drops below a safe operating level or one or more of the input phases are missing. Details of protection circuit operation and explanation of fault indicators is provided below.

A. Manual Reset Protection Circuits

The protection circuits discussed in this section are electronically "latched" to prevent automatic restart when activated. These circuits can be reset ONLY by depressing the red O/C RESET pushbutton on the control box with the TECS 18 in any mode except OFF, or by interrupting the supply power to the TECS 18 momentarily. Note that turning the mode switch to OFF will NOT reset these circuits.

1. Inverter Overloads

The high speed power switching transistors used in the inverter bridge of each motor drive are susceptable to damage by excessive current flowing in the collector-emitter circuit. A small resistance in series with 3 of the transistors in each inverter (transistors Q2, 4, & 6 in Fig. 2-2) is used to sense the emitter current of each. If this current exceeds a safe operating level at any time the overcurrent trip circuit of the driver board associated with the overloaded transistor quickly removes base drive thus interrupting the current flow thru the eimitter. Base drive is helf off for a short time and then reapplied to the transistor. If the emitter current returns to a safe level the system will continue operating with no further action, but if emitter current still exceeds the safe level the base drive is again removed. If after several attempts to reapply base drive, emitter current still exceeds the safe level a signal is sent by the driver board to the associated inverter control board and to the evaporator interface board which shuts down the TECS 18 system and turns on the appropriate O/C TRIP indicator (Evap, Cond, or Comp).

2. Inverter Fault Sensors

To prevent a restart of the TECS 18 system in the event of a single or multiple failure in any of the transistors in the 3 inverter bridge circuits, each inverter is checked for a shorted transistor near the end of the DC bus precharge interval. If a shorted device is detected, the fault sensor shuts down the TECS 18 before attempting to energize the inverters. This

action prevents the possibility of further damage being done to the electronics sections after a power switching transistor failure. When the fault sensor for an inverter is activated it also turns on the appropriate O/C TRIP indicator.

3. Input Power Fault

A sensor in the power deck continuously monitors the input voltage and checks for the presence of all 3 input phases. Low input voltage (approx. 180 VAC) or a missing input phase will cause the input fault sensor to shut down the TECS 18 and turn on the INPUT TRIP indicator. Additionally, a power deck overload signal is included with the input trip sensor. This current sensor shuts down the TECS 18 if the maximum safe current limit for either DC bus is exceeded, and turns on the INPUT TRIP indicator.

B. Self-Reseting Protection Circuits (Automatic Restart)

1. Motor Thermals

All three motors are provided with over temperature thermals. If one or more of the motor thermals should open, circuitry on the evaporator interface card and master control card shut down the TECS 18 and turn on the TEMP/PRES indicator. When the thermal recloses the TECS 18 will restart.

2. Pressure Sensors

If freon pressure in the condenser section drops below the low pressure threshold the TECS 18 will be shut down by circuitry on the evaporator interface card and master control card. Manually reseting the low pressure cutout will restart the TECS 18.

The high pressure cutout operates similarly.

3. Evaporator Thermals

If air temperature i[illegible]de the evaporator section exceeds a safe level the [illegible]aporator [illegible]ermals open and disable the evaporator heaters. [illegible] indicator is lit by these thermals and no other action is taken by the protection circuits. The heaters will be re-energized when the thermals cool down.

C. Fault Indicators

1. EVAP O/C TRIP

Indicates that either an overcurrent condition was detected during operation, or if occuring at turn-on that a shorted transistor was sensed by the evaporator inverter fault sensor.

2. COND O/C TRIP

   Similar to EVAP O/C TRIP but for the condenser inverter.

3. COMP O/C TRIP

   Similar to EVAP O/C TRIP but for the compressor inverter

4. TEMP/PRESS TRIP

   Indicates that either one of the 3 motor thermals has opened or that either the high or low pressure cutouts has operated.

5. INPUT TRIP

   Indicates that either the input voltage has fallen below the minimum safe operating level or that one of the input phases is missing. Additionally a power deck overload will turn on the INPUT TRIP.

D. Effect of Protection Circuits on System Operation

1. EVAP O/C TRIP

   An evaporator O/C TRIP in any mode of operation except TEST will prevent operation of the TECS 18.

2. COND O/C TRIP

   A condenser O/C TRIP in either COOL or AUTO-COOL Mode will prevent TECS 18 operation. In TEST, LOW HEAT, and HIGH HEAT Modes it has no effect.

3. COMP O/C TRIP

   A compressor O/C TRIP in the COOL or AUTO COOL Mode will prevent operation of the TECS 18. In the TEST, LOW HEAT, and HIGH HEAT Modes it has no effect.

4. INPUT TRIP

   An input trip in any mode except TEST will prevent operation of the TECS 18.

5. TEMP/PRES TRIP

   A temperature/pressure trip in any mode except TEST will prevent TECS 18 operation.

   However the two pressure cutouts and the compressor and condenser thermals will not activate the TEMP/PRES trip in the LOW HEAT or HIGH HEAT modes.

E. Internal Fuses and Circuit Breakers

There are no internal fuses or circuit breakers in the TECS 18.

II. Maintenance

CAUTION: This equipment contains circuitry operating at high voltage. Exercise extreme caution when performing tests or making adjustments with portions of the TECS 18 electronics sections exposed.

When making repairs or adjustments on the TECS 18 electronics sections the following procedures should be used to disassemble the various subsections.

A. Power Deck (See Figure 1-a)&(Figure 4-1)

The power deck contains circuitry to produce both high voltage DC Buses, the 10 KHz logic supply, the 12 VDC continuous power supply, and the heater controls.

To disassemble, remove top cover plate of the TECS 18 evaporator section. Remove the counter-sunk machine screws in the cover plate of the power deck and lift off the power deck cover plate. Remove J1 & J2, the two circular connectors on either side of the power deck. The power deck is secured to the evaporator section with 4 machine screws, two are located on the front of the power deck and the other two are in the bottom of the power deck toward the rear (See Fig. 4-1). Remove these screws and lift the power deck vertically out of the evaporator.

The power control and heater control cards are accessable with the power deck cover plate removed and may be removed for repair by unplugging from the power deck mother board. Note that both cards are keyed to prevent exchanging or reversal.

To disassemble the switching regulator, DC-DC converter section with the power deck removed from the evaporator section, remove the counter-sunk machine screws from the small cover plate in the front of the power deck and remove the cover plate. Remove the 4 long countersunk machine screws from the the right side of the power supply section and, one by one, unplug the 3 PC cards inside the power supply from the connectors at the rear and remove (Do not apply excessive force to cards when removing or replacing).

To reassemble, reverse the above procedures.

B. Evaporator Drawer (See Figure 1-a & Figure 4-2)

The evaporator drawer contains circuitry to control: the activation of the two high voltage DC Buses, the activation of the 3 motor drives, the speed of the compressor and evaporator Fan, the activation and control of the two heater sections, and the evaporator inverter.

To disassemble, remove the pan head machine screws from the edges of the front cover of the evaporator section and slide the drawer out of the evaporator just far enough to allow access to the 4 circular connectors in the rear of the drawer. Remove JP101, JP102, JP103, & JP105 if attached and remove the drawer from the evaporator.

Remove the remainder of the screws in the front cover including the 4 screws near the evaporator input plug. Remove remote control box if present, and lift the cover plate off the evaporator.

Place the evaporator section on its side with the RFI filter (input plug) toward the bottom to prevent the filter from falling when mounting screws are removed. Remove the 4 screws from the back of the drawer near J105 and lift the RFI filter out.

Remove the 4 countersunk screws from the bottom of the evaporator section and unplug the two, 2-pin Molex connectors from the evaporator power board located inside the evaporator drawer at the bottom. Lift the power board out far enough to allow access to the grounding strap at the lower left of the card. Remove screw from grounding strap and remove evaporator power board.

Remove the evaporator enclosure mounting screws from the rear and place the evaporator drawer on its back. Remove all PC cards from the evaporator mother board (note that all cards are keyed to prevent reversal or exchange). Remove the evaporator mother board mounting screws, and the two screws in the remote control box socket. Remove the evaporator enclosure and lift the mother board to gain access to the evaporator inverter transistors and harnesses.

To reassemble reverse the above procedure.

C. Compressor/Condenser Drawer (See Figure 1-b & Figure 4-3)

The compressor/condenser drawer contains circuitry to control the speed of the condenser fan, both the compressor and condenser inverters, and the equalizer solenoid valve driver.

To disassemble, remove pan head machine screws from the edges of the front cover of the drawer and pull out by the handles on the cover.

Remove the mounting screws in the heat sink cover plate and remove cover plate. Remove countersunk screws from the edges of the heat sink and lift up front edge of heatsink. Pivot heatsink on back edge and lay heatsink immediately behind the drawer.

The compressor and condenser frequency control cards and inverter control cards, and the compressor/condenser interface card may be removed for repair. All cards are keyed to prevent reversal or exchange.

The compressor and condenser driver boards may be removed by removing the 3 countersunk screws near the top edge on either side of the drawer, and then pulling the cards out of the connectors on the bottom of the drawer.

D. Internal Adjustments

Certain important parameters of the overall TECS 18 operation may be adjusted for optimum results. These adjustments are made by trimmer potentiometer on certain control cards in the electronics subsections. Only those adjustments specifically called out below should be made, adjustment of other trim pot settings may result in damage to the electronics section or other portions of the TECS 18. The adjustments called out below should only be made by qualified personnel and with proper equipment. Maladjustment of these settings can prevent proper system operation and be potentially damaging to the TECS 18.

1. Evaporator temperature control range adjust. (Evaporator drawer, master control card-P2)

   The TEMP control on the control box has approximately a 10°F range of adjustment. As shipped from the factory this range is about 68°F to 78°F. To lower this range of adjustment turn P2 on the master control card clockwise (approx. 2°F per turn).

2. Compressor turn-on delay adjust. (evaporator drawer, master control card - P1)

   The delay after system turn on until compressor turn on is adjustable from approx. 10-100 seconds. Turning P1 on the master control card clockwise increases the delay (approx. 5 seconds per turn).

3. Condenser temperature adjust. (comp/cond drawer, interface card P8)

   The condenser fan speed is controlled by condenser temperature. As set at the factory it varies from minimum speed at approx. 95°F to full speed at approx 120°F. This range may be raised by turning P8 on the compressor/condenser interface card clockwise (approx. 3°F per turn)

4. Compressor Minimum Speed

   a) Low Temperature (comp/cond drawer, interface card P3)

      At low outside temperatures (less than approx. 120°F) the compressor minimum speed is set by P3. Turning P3 clockwise reduces the minimum compressor speed.

   b) High Temperature (comp/cond drawer, interface card P4)

      At high temperatures the compressor minimum speed is set to a higher level to prevent lock-up. This is adjusted by P4. Turning P4 clockwise increases minimum speed.

E. Routine Maintenance & Lubrication

No routine or periodic maintenance is required for the electronics sections of the TECS 18. No lubrication is required for any of the electronics sections.

F. Test Mode Operation

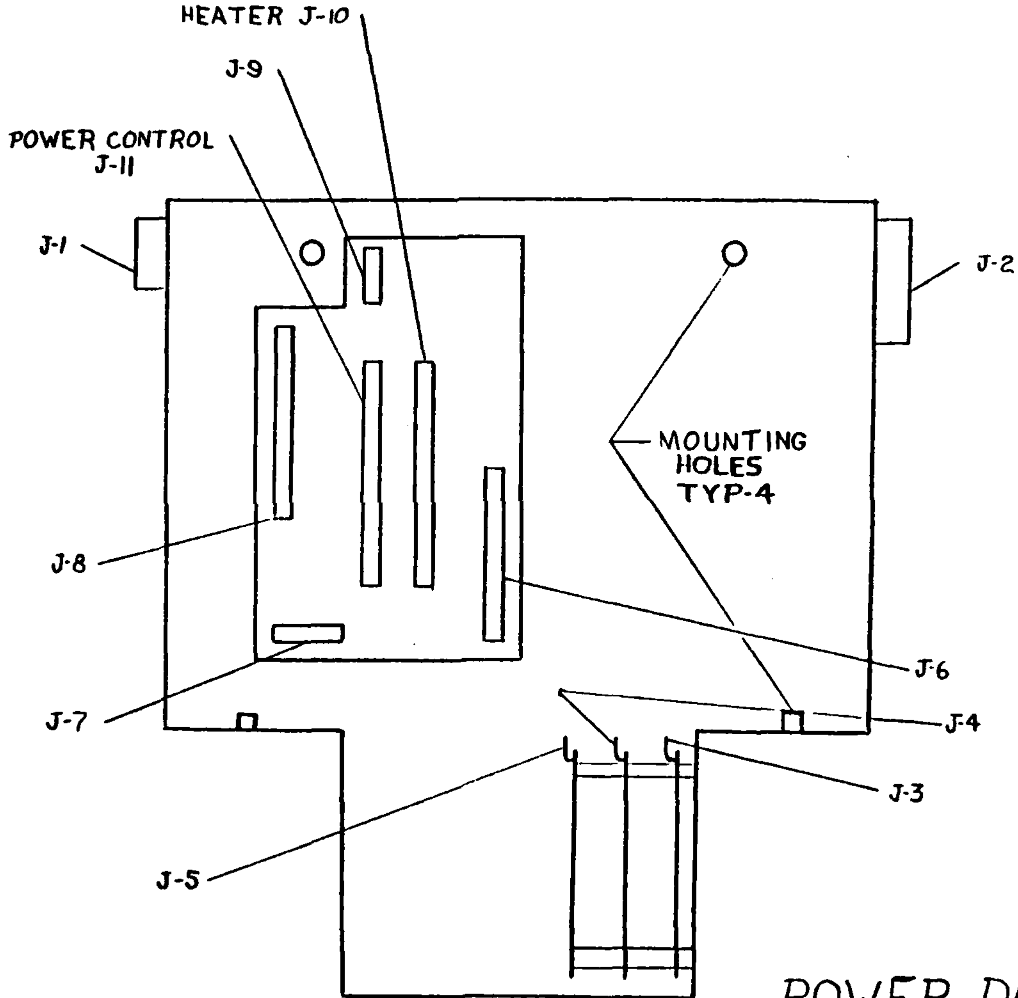
As an aid for making adjustments and in troubleshooting the TECS 18 a TEST Mode is provided. In this mode the two high voltage DC buses and the two heaters are disabled. In this mode various waveforms may be examined and overall system operation checked out without powering the motors or heaters.

To operate the TECS 18 in the TEST mode turn mode switch to OFF then to TEST. The TEST mode will not function if the system has been in any other operating mode (Auto-Cool, Cool, Low Heat, High Heat) prior to switching to the TEST mode.

CAUTION: High voltages are still present on portions of the circuitry in the TEST mode. Use care when making tests or measurements with power on the TECS 18.

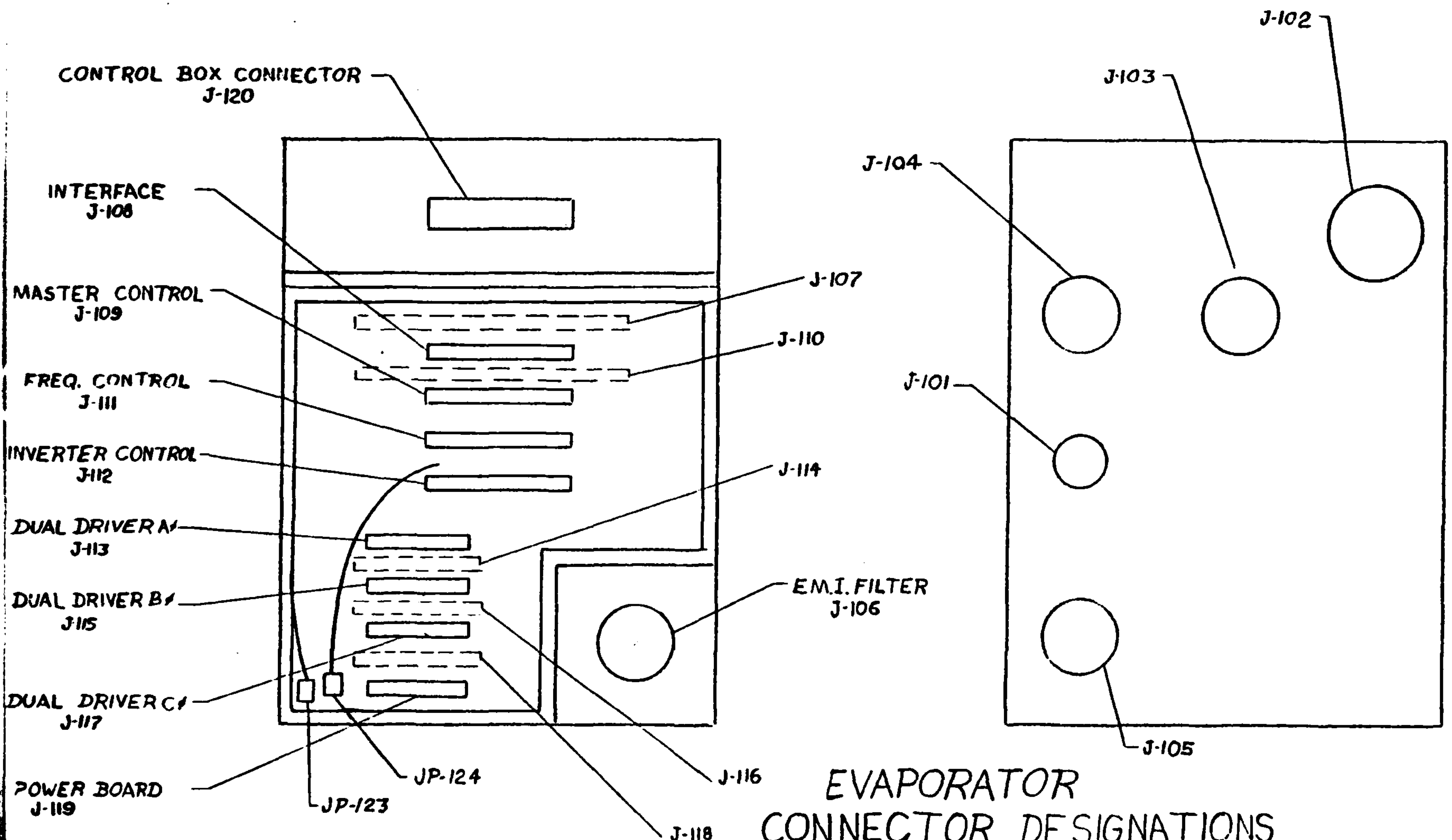
G. Lamp Test Switch

To verify operation of the front panel lamps in the control box a lamp test switch is provided. Depressing the lamp test switch should light all lamps with the mode switch in any position except OFF.



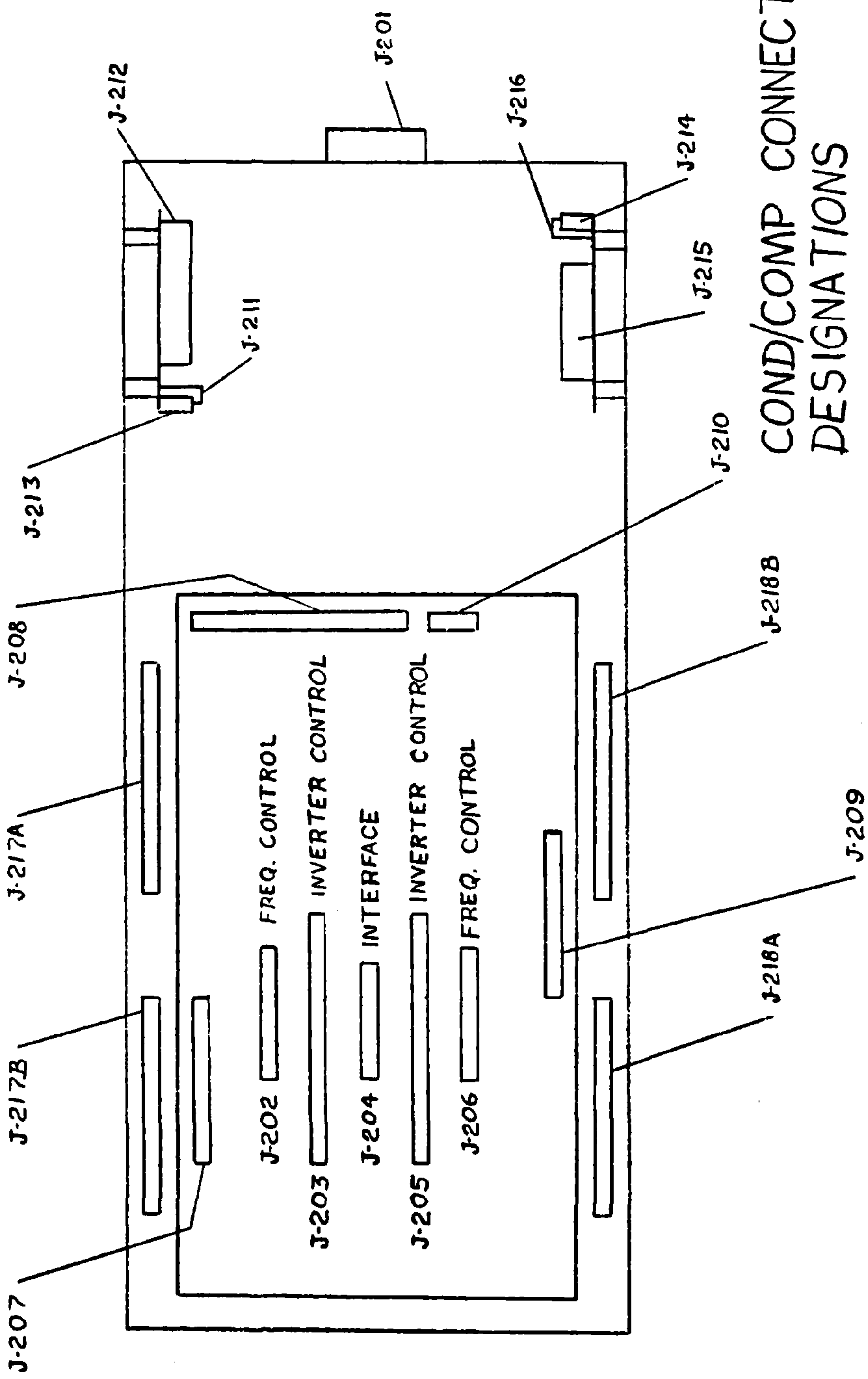
POWER DECK
CONNECTOR DESIGNATIONS

FIG-4-1



EVAPORATOR
CONNECTOR DESIGNATIONS

FIG-4-2



COND/COMP CONNECTOR DESIGNATIONS

FIG-4-3

APPENDIX A

List of Drawings

Drawing Number	Rev.	Type	Title	Size	
75-301-058-001	0	Schematic	Power Supply	D	P
002	0		Switching Reg. Driver	C	P
003	0		Power Supply Control	D	P
004	0		Power Supply Filter	C	
005	0		Dual Inverter Driver	D	P
006	0		Power Supply Board	C	
007	0		Display Bd. & Remote Con.	D	
008	0		Master Control	D	
009	0		Condenser Hex Driver	E	P
010	0		Freq. Con. Sine Wave PWM	D	P
011	0		Inv. Cont. Sine Wave PWM	D	P
012	0		Compressor Hex Driver	E	P
013	0		Evaporator Interface	D	
014	0		Heater Control Card	D	
015	0		Comp/Cond Interface	C	
016	0		Cond. Power Supply	C	
017	0		Comp. Power Supply	C	
018	0		Evap. Mother Board	D	
019	0		Con/Comp Freq. Control	D	P
020	0		Cond/Comp Mother Board	D	
021	0		Power Deck, Mother Bd.	C	
022	0		Comp/Cond Heat Sink	D	
023	0		Power Control Power Dk.	D	
025	0		EMI Filter	C	
026	0		Junction Box	D	
027	0		Cond. Inverter Cont.	D	P
028	0		Comp. Inverter Cont.	D	P
75-302-015-001	0	Wiring Dia.	Overall Connection	D	
002	0		Power Supply Conn. Dia.	D	
003	0		Heater Connection Dia.	B	
004	0		Power Deck Wiring Dia.	C	

Drawing Number	Rev.	Type	Title	Size	
75-302-015-005	0	Wiring Dia.	Comp/Cond Wiring Dia.	C	
006	0		Pwr. Deck to Mother Bd. to Connectors	D	
007	0		Evap. Wiring Dia.	C	
75-303-008-001	0	Blk. Dia.	Block Dia. Ft. Belv.	D	
75-305-019-001	1	Drill Guides	Switching Reg. Driver	C	P
002	0		Power Supply Control	C	P
003	0		Power Supply Filter	C	
004	0		Dual Inverter Driver	C	P
005	1		Evap. Pwr. Supply	C	
006	0		Control Panel	B	
007	0		Display Bd. Drill Guide	C	
008	0		Master Control	C	
009	0		Cond/Comp Hex Driver	D	P
010	0		Freq. Cont. Sine Wave PWM	C	P
011	0		Inverter Cont. Sine Wave	C	P
012	0		Power Supply Section	D	
013	0		Junction Box & Cond/Comp Application Dwg.	C	
014	0		Heater Control	B	
015	0		Evap. Interface	C	
016	0		Power Deck Mother Bd.	C	
017	0		Cond/Comp Interface	C	
018	0		Cond./Comp Pwr. Supply	C	
019	0		Evap. Mother Bd.	C	
020	0		Freq. Control Comp/Cond	C	P
021	0		Comp/Cond Mother Bd.	D	
75-306-015-001	1	Mechanical Dia.	Power Deck Encl.	D	
002	0		Pwr. Deck Encl. Covers	D	
003	0		Evap. Encl.	C	
004	0		EMI Filter	C	
005	0		Junction Box	D	
010	0		Heatsink Cover, Back Evap.	D	
011	0		Cover,Front,Evap.	C	
012	0		Cover & Front Panel Comp/Cond. Encl.	D	

Drawing Number	Rev.	Type	Title	Size	
75-306-015-013	0	Mech. Dia.	Control Enc.	D	
015	0		Cond/Comp Module	C	
016	0		EMI Filter Mtg. Bkt.	C	
017	0		Cond/Comp Drawer	C	
75-308-009-002	0	Mech. Assy Dia.	Assy, Evap. Enc.	D	
004	0		Pwr. Supply Section	D	
005	0		Pwr. Deck to Evap. Hrns.	D	
006	0		3 Phase Power Harness	C	
007	0		3 Phase Power Harness	C	
008	0		3 Phase Power Harness	C	
009	0		Harness/Evap. Blk. Hd.	C	
010	0		Thermal Switch Harness	C	
011	0		Temp. Sensor Harness	C	
012	0		Cond. Junc.to Blkhd. Hns.	C	
013	0		Mtg. Bkt. Temp Sensor	C	
014	0		Mtg. Bkt. Temp Sensor	C	
015	0		Harness Comp. Junc. Box	C	
016	0		Hns. Cond. Motor to Junction Box	C	
017	0		Harness Junc. Box Aux.	C	
018	0		Assy Cond/Comp Drawer	D	
019	0		Heatsink Comp/Cond Assy	D	
021	0		Evap. Heatsink	D	
022	0		Triac Assy. Pwr. Deck	C	
023	0		Pwr. Deck Assy	D	
025	0		Trans. Linear Pwr.	B	
029	0		Output Inductor	B	
030	0		Cond/Comp EMI Filt. Assy	D	
75-310-002-001	0	Silkscreen Pat.	Cont. Panel Marking Pat.	B & C	
75-702-015-001	1	P.C. Assemblies	Switch Reg. Driver	C	P
002	1		Power Supply Control	C	P
003	1		Power Supply Filter	C	
004	0		Dual Inverter Driver	C	P
005	0		Evap. Pwr. Supply	C	
006	0		Display Bd. Assy.	C	
007	0		Master Control	C	

Drawing Number	Rev.	Type	Title	Size	
75-702-015-008	0	P.C. Assy	Cond Hex Driver	D	P
009	0		Freq. Cont. Card Sine Wave PWM	C	P
010	0		Inverter Cont. Card Sine Wave PWM	C	P
011	0		Comp Hex Driver	D	P
012	0		Heater Control	B	
013	0		Evap. Interface	C	
014	0		Pwr. Deck Mother Bd.	C	
015	0		Cond/Comp Interface Cd.	C	
016	0		Cond. Pwr. Supply	C	
017	0		Comp. Pwr. Supply	C	
018	0		Evap. Mother Bd.	C	
019	0		Comp/Cond Freq. Cont.	C	P
020	0		Comp/Cond Mother Bd.	D	
021	0		Pwr. Control Card	B	
022	0		Cond/Comp Inverter Cont.	C	P

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